POLE INSPECTION AND MAINTENANCE

By C. H. Amadon, Consultant
Electric Engineering Division

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C. H. Amadon

This paper and the oral presentation of it will be supplementary, and with the discussion which should follow, should add considerably to your own knowledge of poles and the problems they present in your service lines. It seems appropriate although the assigned topic is "Pole Inspection and Maintenance" that you should have something more than a casual acquaintance with poles and it is my purpose to present as briefly as I can the information about them that will be useful to you. Although poles in service are your principal concern, it may be desirable to go somewhat farther back than your acquisition of them and to lay a background on which to build up the information about poles in line and their maintenance. We shall cover in more or less detail the kinds of poles in common use, their characteristics, the preservatives and preservative treatments applicable to them. These are the background details. We shall then cover in somewhat more detail the hazards to which poles are subjected in line; methods of inspecting them for deterioration or damage; and remedial or preventive measures which can be taken to avoid loss in service and injury to the public and our own employees.

POLES

Species of Pole Timber

There are in general use throughout the country today nine species of pole timber from among the very considerable number of tree species in our native forests. The use of southern pine (5 distinct species) Douglas fir, western red cedar, western larch, and lodgepole pine reflects a choice influenced in part by availability and delivered cost in the roughly four geographical regions into which the United States may be divided.

Southern pine, although more widely distributed than any of the other kinds of poles is almost exclusively the one species used in the southeastern states; Douglas fir, originating in the Pacific Northwest, is used largely on the Pacific coast; western red cedar originating in Washington, Idaho and Montana is a favored species throughout the northern states and extensively used in the Pacific Northwest; western larch is a relatively recent (1945) addition to the list of accepted pole timbers, and is used in the same areas as western red cedar; lodgepole pine originates in the Rocky Mountains from central Colorado northward and is mostly used in its native region, although considerable numbers have been shipped eastward. Other species in minor usage are red (Norway) pine and jack pine in the Lake States region, and ponderosa pine in parts of California.

Rated Strength

Each of the pole species has been assigned a strength rating (modulus of rupture in static bending)based in all but two of the species on mechanical tests of pole size specimens. Those based on actual tests are --

southern pine rated at 7400 pounds per square inch,
lodgepole pine rated at 6600 pounds per square inch,
western red cedar rated at 5600 pounds per square inch,

The other species are —

western larch rated at 8400 pounds per square inch,
Douglas fir rated at 7400 pounds per square inch.

In the latter two cases the ratings were established by a committee sponsored by the American Standards Association; the rating for western larch was computed from the strength rating for small clear specimens of the wood as published by the Forest Products Laboratory at Madison, Wisconsin. The rating for Douglas fir poles was set at the same value as for southern pine on the basis of the generally accepted equal values for lumber and timber of the two species.

The validity of the assigned ratings has been questioned because of the non-uniformity of test methods and of the condition of the test specimens at time of the test, and the possibility that the timber itself is not now of the same quality as that which was previously tested and on which the present ratings were based. Some of the tests were made with the poles supported in a horizontal position in a rigid crib, with the load applied at a fixed distance from the top end. In this case, the poles were tested as cantilever beams, which they are in service unless guyed or braced. In other cases the poles were tested as simple beams, supported near each end, with the load applied near or at the distance from the butt end equal to the depth of setting for the pole under test. A further variant was in the moisture content of the poles at time of test; some were essentially "green" or unseasoned; in others, the moisture content was at or below the fiber saturation point and in a condition with respect to moisture at which further reduction in moisture content of the wood results in an increase in strength. There seemed to be no principle by which the strength values derived from different methods of test and from tests of poles in different states of seasoning could be reconciled. There has been no evidence however that the strength of the poles has been over rated. Nevertheless, there is now in progress at the Forest Products Laboratory a series of new tests sponsored by the American Society for Testing Materials. These tests are designed to eliminate the two principal objections to the previous tests and as nearly as possible to duplicate all of the controllable details of test for each specimen of each of the five kinds of pole timber.

Standard Dimensions of Poles

Under the sponsorship of the American Standards Association another subcommittee established dimensional standards for poles of each species in seven classes (1 to 7) in lengths up to the maximum of available poles for these, the limiting dimensions (circumference) applies at the top and at six feet from the butt end; in addition, three classes (8, 9 and 10) were classified on the basis of top circumference only. The dimensions at six feet from the butt were set at such values, using the standard fiber strength ratings that all poles in a given class would hold the same load regardless of the species of timber; in like manner all poles of a given class would hold the same load regardless of length. Poles in Class 7 are designed to sustain a load of twelve hundred pounds applied at two feet from the top; poles in each larger class are designed to sustain a 25 percent greater load than the next smaller pole.

Specifications for Poles

Still another committee of the American Standards Association established standards for quality of acceptable poles, placing limits on, or prohibiting certain strength reducing features, on deviation from straightness, on manufacturing (bark removal, trimming and thelike). These specifications have had general acceptance throughout the country, and have been modified by some pole using interests only as their own needs indicated.

Durability of Poles

These five kinds of pole timber fall naturally into three groups based on natural durability or resistance to fungus attack (decay); western red cedar and western larch have a notably durable heartwood encased in a relatively thin non-durable sapwood ranging in thickness from 0.5 inch to 1.25 inches; Douglas fir and southern pine have a fairly durable heartwood encased in a non-durable sapwood of from 0.7 inch to 2 inches in Douglas and from 1.25 inches to as much as 4 inches in southern pine; in lodgepole pine the non-durable heartwood is encased in non-durable sapwood ranging in thickness from about 0.5 inch to 2.5 inches in thickness.

Because the sapwood of all species of pole timber is not resistant to decay, infection of untreated sapwood in contact with the soil is certain except in very wet or very dry locations. Experience has shown that the thin sapwood in the ground section of western red cedar and western larch will be practically destroyed by decay within the first five years; in lodgepole pine the period may be from five to seven years; in Douglas fir and southern pine from seven to ten years. Thus in an untreated pole or one in which the preservative was not effective having average sapwood thickness for its species and a 30-inch circumference at the ground line when placed, the loss of the sapwood results in less in strength about as follows:

Western red cedar	40% in about 5 years
Lodgepole pine	70% in about 7 years
Douglas fir	77% in about 10 years
Southern pine	total failure in about 10 years.

In lodgepole pine however the loss in strength may continue at an undiminished rate because of non-durability of the heartwood, so that total failure may occur in about 10 years or sooner.

Penetrability of the Wood by Preservatives

The heartwood of all species of pole timber is highly resistant to penetration by any of the commonly used standard wood-preservatives using present treating plant equipment and methods. However, when properly conditioned the sapwood can be satisfactorily impregnated with these preservatives resulting in a high degree of resistance to destruction by fungi and wood-eating insects.

Conditioning of the wood involves generally the removal of a considerable quantity of the sapwood water which is present in the wood cells comprising the sapwood. The poles may be naturally conditioned by exposure to the air in seasoning stacks. Where this can be done without risk of fungus infection and decay, as in regions

of relatively low atmospheric humidity, air-seasoning is to be preferred over all other methods. The slow loss of moisture during air-seasoning is desirably accompanied by shrinkage which results in the development of checks or lengthwise openings extending from the surface toward the center of the pole. When these checks, occur before the poles are subjected to the treating process, the preservative during treatment enters to the full depth of them thus preventing the later exposure of untreated wood which could result when deep checks develop after treatment of unseasoned poles. Air-seasoning is highly essential in the case of lodgepole pine, because of its non-durable heartwood; air-seasoning is to be preferred for western larch and western red cedar to facilitate penetration of the sapwood by non-pressure process. Air-seasoning is not wholly practicable for conditioning Douglas fir and southern pine largely because the local or regional atmospheric conditions are unfavorable. These timbers are artifically conditioned just prior to unpregnation, by heating in the preservative under a vacuum (Douglas fir) or by steam and vacuum (southern pine).

PRESERVATIVES

At the outset of the wood-preserving industry coal tar creosote was used almost exclusively, although there was a relatively small output of materials treated with toxic salts like copper-sulphate, zinc chloride and the like in water solutions. Creosote originally was imported from England, later from continental Europe, still later from Japan. Meantime the domestic production of creosote was stepped up to keep pace with the expanding demand for preserved poles, ties and structural timbers.

Creosote was not acceptable as a wood-preservative for universal use. Creosoted timber could not be successfully painted; the odor of it was considered objectionable, or prevented its use where commodities could be contaminated as to odor or taste. Moreover, the improved art of coal tar distillation resulted in the recovery of many by-products having greater commercial value, than as components of creosote. This had the effect of rendering coal tar creosote a variable commodity, having at times, undesirable characteristics as well as unknown effectiveness as a wood-preservative. New preservatives were introduced from time to time; water borne salts have not been accepted generally; oil borne preservatives such as copper naphthenate and pentachlorophenol appear to be the most acceptable but at present only pentachlorophenol in solution in petroleum (5% by weight) is in extensive use. This preservative solution is considered the equivalent in toxic property with the kind of creosote which has given long time protection to wood; it is used wherever creosote has been used (except for marine piling and railroad ties) and for many purposes creosote is objectionable.

There have been periods of increased demand for poles accompanied by a shortage of creosote. Such a period occurred during 1946 to mid 1948. When there was a tremendous backlog of demand for poles as the war ended; there was a concurrent critical shortage of creosote because of the complete stoppage of importations. As a result, solutions of creosote with petroleum, and with refined tar, had to be used; by-products of the production of illuminating and cooking gas, and distillates from admixtures of coal tar and water gas tar were offered and used to some extent; penta solutions were accepted but a shortage of penta developed during 1947. During this period, many thousands of poles were treated and placed in service, in which insufficient quantities of a substandard preservative were used. The results are now becoming evident in the complete deterioration in the section below ground of an increasing number of poles in line.

METHODS OF PRESERVATIVE TREATMENT

Two standard methods of impregnating wood with preservatives are in common use; a method by which the preservative is forced under pressure into the timber, and a method by which the wood simply absorbs the preservative under none but atmospheric pressure.

Pressure Processes

In current pressure-treating practice, poles may be impregnated by the full-cell, or Bethell process or by the empty-cell or Rueping process. The full-cell process is generally specified where deep penetration and a heavy concentration of preservative are desired, as for marine structures, or in tropic climates where exposure to fungi and insects is severe. The empty-cell process is generally specified where deep penetration is desired but where lighter concentrations of preservative are adequate for the conditions of exposure. In the first or full-cell process the specified quantity of preservative is pressed into the timber and the treating process is terminated; in the second or empty-cell process an excess of preservative is pressed into the timber, and recovered by the combined effect of two stages in the process which are not a part of the full-cell process. These two stages are, a period of air pressure in excess of atmospheric pressure before the impregnation period and a vacuum following the impregnation period and after the unused preservative has been withdrawn from the cylinder.

Non-Pressure Processes

The non-pressure process is simply the submersion of the poles in the preservative, where treatment full length is desired, or immersion of the butts of the poles where butt treatment only is desired. The first stage of this treatment is in hot preservative (about 230°F.) for from 6 to 10 hours; this is followed usually by quick removal of the hot oil and introduction of cool preservative (usually at about 100°F.) duration of this phase is from two to four hours. aIn some cases the hot preservative is not withdrawn but is simply allowed to remain until its temperature has dropped to 150°F. The hot period tends to expel air and moisture from the sapwood cells, thus facilitating absorption of the preservative during the cooling or cold oil period.

The non-pressure process is not generally used with pole timbers having deep sapwood; it is most commonly used in treating western red cedar and western larch.

RESULTS OF TREATMENT

Results of treatment by pressure processes are customarily defined in terms of retention and of penetration by the preservative. The required quantity of preservative is generally defined in terms of pounds per cubic foot of total volume of the pole, and is determined by means of calibrated measuring devices. Less frequently, the retention may be determined by extraction of the preservative from representative samples of the treated wood and relating that quantity to the volume of wood in the sample. The retention in poles treated by non-pressure process in open tanks cannot be accurately determined by gauges, and is not generally specified. The criterion for acceptance of these poles is the depth of penetration of the preservative, expressed in inches of depth from the surface (of the pole) and as a percent of the sapwood thickness. Penetration is measured on slim cores taken with a special tool from each of a specified number of poles in any lot offered for acceptance. Thus, for southern pine, treated

to an 8 pound retention, the required penetration is 2.5 inches unless the penetration is also 85 percent of the sapwood thickness; in western red cedar the acceptable penetration is not less than 0.5 inch unless it also is 100 percent of the sapwood thickness.

Specifications

Standard specifications such as those issued by the American Standards Association may be adopted in entirety by producers and users of the covered commodities, or modified by a user to meet his specific needs. Thus, REA has adopted the standard pole specifications issued by the American Standards Association with a few changes and additions; the specifications for preservatives and for treatment are based on specifications approved by the American Wood Preservers' Association. Adherence to these REA specifications in the selection, manufacture and treatment with approved preservatives can be expected to result in high grade poles having the desired life in service.

Experience has shown however that departures from the standards usually results in a sub-standard article having a doubtful service life. Some of the departures from standard may have been authorized after consideration of the temporary emergencies and shortage of supply; some departures have been the result of carelessness or inefficiency on the part of producer or inspector. The results are now becoming apparent in the early failure of a considerable number of poles in service; this indicates the need for two specific activities in which the cooperatives have a primary interest and one in which the field engineer and the cooperative have a joint and primary interest. The first one relates to sub-standard poles already in use; it involves consideration of the problems posed by the substandard poles; prompt development of plans to inspect where there is reason to believe, or evidence to show, that the poles are already seriously deteriorated; and initiation of a repair or replacement program . The second activity involves specific plans for inspection of new poles at time of delivery, and prompt reporting in detail of any non-specification quality so that appropriate action can be taken promptly.

INSPECTION OF POLES IN LINE

Inspection of poles in line is nothing more nor less than an examination in sufficient detail to determine the present condition of each individual pole. Based on the conditions revealed by this inspection, an appraisal or estimate of the remaining service life can be made with a fair degree of accuracy. Such an inspection and appraisal with appropriate action based on them can prevent a large part of the economic waste resulting from too early removal of poles from line, and the menace to property and life, and disruption of service, which may result from failure of a pole.

It should not be assumed that inspection and appraisal of poles can be based on a set of hard and fast rules of procedure and on strict mathematical formulae. Rather it should be understood that inspection should follow a general routine and a general formulae and that interpretation of the results must be made with judgment based on experience.

However, a working knowledge of the agencies (other than aging) which affect the strength and stability of a pole in service is helpful to those engaged in inspection and evaluation of the remaining service life at any inspection date.

Deterioration and Damage to Poles in Line

The destructive agents to which poles in line are exposed may be grouped in two categories. In one group are wood-destroying insects and fungi which consume wood substance very slowly. In the other group are storm, fire, and collision which may weaken or suddenly render the pole useless, and woodpeckers which if very active may quickly do considerable damage to individual poles. Destruction by fungi and insects may well be referred to as deterioration to distinguish it, for purposes of discussion, from the effect of fire, storm, collision and woodpeckers referred to as damage.

Deterioration may actually begin in the ground section within the first year after the setting of an untreated cedar pole and it may progress rapidly during the first few years in the non-durable sapwood, but more slowly threafter in the decay-resistant heartwood. In the case of properly treated poles of all species, deterioration of the treated wood is almost imperceptible even over a long period of years. Thick sapwood poles, if not deeply impregnated, may show early decay in the untreated inner sapwood portion, resulting eventually in loss of enough sound wood to render the pole useless.

Damage may take place almost immediately, or may be deferred for many years, or may never happen. In any case damage becomes evident as soon as it happens and may be dealt with as soon as practicable. Of itself, damage may not be sufficiently extensive to warrant removal of the pole, but it may produce openings through which fungi and insects may enter and begin their slow deterioration of the pole.

Wood-Destroying Fungi

It is not the intention here to discuss these destructive agents at great length, but instead to point out some of the important factors about them as a group and some of the specifically important facts about those which are commonly found in poles.

Wood-destroying fungi infect wood in two ways. Spores or "seeds" of the fungus are produced in enormous numbers and are carried by birds and insects or blown about very widely, finding lodgement on practically everything on or above the ground. A conspicuous example of spore production is the common puff-ball frequently to be found in fields and pastures. The cloud of "smoke" which arises when a ripe puff-ball is crushed is composed of millions of spores. Spores of wood destroying fungi which are deposited on wood in favorably moist condition for their development, almost immediately begin to grow in much the same fashion that planted seeds grow. Or, the fungus itself may be present in the soil into which a pole is set, in which case if the pole is untreated, it may become infected almost immediately. Once the fungus, whether from spores or from the plant itself, becomes well established in a pole it will continue to grow as long as conditions are favorable.

Moisture and air are necessary to the life of the fungus, and if either is lacking or restricted, the growth of the fungus is prevented or inhibited. Wood that is thoroughly and constantly wet does not rot because air is lacking. Wood that is thoroughly and constantly dry does not rot because moisture is lacking. An untreated pole set in a swamp usually decays just above the ground or water line, because air is lacking below that line; such a pole set in deep loose sand or gravel usually decays from a few inches below the ground line downward because sufficient moisture is lacking above that line. In most soils however, the region of greatest decay is from just above the ground line to 10 to 15 inches below that line.

Wood-Destroying Insects

Carpenter ants, the large black, and the black and red species, should be considered as major destructive agents of cedar poles, and care should be taken to detect their presence. These ants seem to be especially attracted to poles with internal decay or cavities, which they enter and enlarge for nesting purposes. The points of entry are usually close to the ground line although some cases have been observed where the points of entry and location of greatest damage were several feet above ground. Even a few ants noticed in excavating around a pole for inspection purposes may be an indication that the pole is infested. Woodpecker holes in a pole are frequently to be taken as an indication that the pole is infested with ants. Tapping the pole to detect internal unsoundness may arouse the colony and cause many of the ants to appear for investigation of the disturbance. Carpenter ants do not eat the wood; they remove it in fine sawdust-like particles which they carry to the outside of the pole. If their principal workings are above the ground line this fine wood dust accumulation is usually very noticeable and is a sure indication that ants are or have been at work in the pole. Since their workings are primarily used as chambers in which their eggs are deposited and their young larvae are fed, carpenter ants are unlikely to leave a pole unless frequently disturbed or unless the nest is made unhabitable or objectionable to them. Wood preservatives injected into the nest through holes bored for the purpose have been found notably effective in destroying a colony or causing the ants to leave the pole.

Termites are soft grayish-white insects commonly but erroneously called "white ants". Because of their widespread distribution throughout the United States and because cellulose is their principle article of food these insects are of interest as potential destroyers of untreated poles and other wood in structures in the electric and telephone plant.

In general termites are classified as (a) subterranean termites, (b) damp-wood termites and (c) dry wood (aerial) termites. Termites of the first group are found in practically all parts of the country; those of the second group are found in the Pacific Coast States and are notably prevalent in California; those of the third group have been found only along the coast from Virginia to Florida and Texas and along the Mexican border to California.

Subterranean and damp-wood termites have much the same life habits. Both varieties inhabit the soil or wood in contact with the soil and require considerable moisture. Subterranean termites if present, will usually be found in outer decaying wood from the groundline downward; damp-wood termites may be found in poles just above and not far from the ground line. Dry-wood termites, as the name implies, do not need moisture, and seem to prefer dry conditions. They are found in poles only in the aerial section or sometimes in crossarms and insulator pins.

Termites appear voluntarily in the open air only during the swarming season, when large numbers of adult males and females leave the home nest. These flying termites, during this flight season have black bodies and pearl-gray wings which are considerably longer than their bodies. In california the flight season for the subterranean type is in the autumn on sunny days after the seasonal rains begin, whereas the majority of the damp-wood termites swarm at any time between July and November when warm, sultry atmospheric conditions prevail. Elsewhere subterranean termites swarm in spring and autumn.

Their ability to fly is limited and unless blown to greater distances their flight usually ends within about 100 yards. At the end of their flight termites cast their wings, seek a mate and together seek out and prepare a new home. The subterranean species usually enter the ground or some suitable location like an old stump or log or a pole in contact with the soil; the damp-wood species rarely enter the ground but are attracted to some decaying piece of wood which they enter at a point above but close to the ground. Unquestionably very few mated pairs survive the swarming flight and the hazards of preparing a new home. Those which succeed however begin at once the establishment of a new colony, the increase of which is very slow for the first two years. By the end of four years or more under favorable circumstances the colony may have increased sufficiently to produce a new swarm.

The history of the swarming flight, mating and establishment of new colonies of dry-wood termites is much the same as for the other types, except that the mated pair enter some wooden structure above the ground, seal themselves in and never leave the nest. They reproduce very slowly but are rarely found until their damage has been extensive.

Although termites are capable of consuming sound wood, the damp-wood type and the subterranean type apparently prefer wood which has already been attacked by a wood destroying fungus provided however that the fungus is not a cellulose destroyer. This apparent preference is because cellulose is the only part of the wood substance which termites can digest. These two types of termites can usually be controlled by the same measures applied against fungus attack. The dry-wood termites attack in the dry portions of a pole and because they may remain undiscovered until extensive damage reveals their presence, remedial measures are of little practical use. For this reason only full length treated poles should be used when dry-wood termites are likely to be found.

Fire, Lightning, Collision, Woodpeckers

The extent of damage by fire, lightning and collision can be readily observed and appraised on the basis of judgment and application of the general rules relating to pole inspection.

In the case of a fire damaged pole it should be possible to reach a reasonably sound conclusion as to the existing damage and whether or not the fires are likely to be recurrent, as for example, grass fires, or weed burning by highway maintenance forces. In such case new damage during the next inspection period might well be of sufficient extent to weaken the pole seriously.

Lightning damage may be superficial or may shatter the pole badly; appraisal of the damage is purely a matter of judgment. Some pole positions are struck repeatedly; consideration should therefore be given to a recommendation for installation of lightning protection.

Damage by collision should also be appraised according to the inspector's best judgment. The recommendation, in case of need for replacement, should include relocation if it appears that the present location of itself contributes to the collision hazard.

Woodpecker damage is largely mechanical and should not invariably be considered a cause for condemnation; the attacked pole should be carefully inspected for associated

decay or other damage and appraised accordingly. In some cases woodpecker attack is associated with internal decay or insect infestation; the pole should therefore be appraised primarily on the basis of decay and insect damage. In other cases the attack is associated with a "ring shake" which is a separation between growth rings and rarely affects the strength of a pole sufficiently to warrant replacement. A large hole, one of sufficient size, to admit the bird itself, usually indicates a nexting cavity; in such case the pole may be seriously weakened at the location of the hole.

Other Reasons for Removal or Replacement

Removal or replacement of poles for reasons other than deterioration or damage may be necessary in some cases. Poles may be of insufficient height, where for example, recently added or proposed additions to service attachments do not allow sufficient clearance between the ground and the attachments, either at the pole or between poles, or between trees where trimming rights cannot be obtained, or where farm lanes or field entrances made since the building of the line require higher poles to provide for safe passage of farm equipment.

Some poles may be in locations creating a possible public hazard, as for example, where road improvement has brought the traffic lane too close to the pole. This hazard may be particularly serious in the case of poles on the outer side of a curve in a high crowned road or on a down grade where speed or road surface conditions may tend to throw vehicles off the roadway. In some cases road grading may have lowered the ground line of a pole sufficiently to make it unstable; such poles may be reset, if long enough, or a guy may be installed, or if neither of these alternatives is practicable the pole should be replaced. Some poles may be removed and not be replaced in lines where a program of respacing is involved.

In still other cases involving several poles consideration should be given to the section as a whole. By way of illustration, assume that, in a section of five poles, the first and fifth poles are recent replacements. The middle pole should unquestionably be replaced, and the other two are "questionable" or "borderline" poles. If the middle pole is replaced the other two deteriorating poles will each be backed up by good poles, and probably adding several years to the life of the intermediate poles. On the other hand, there might be real economy in the long run if all three poles were replaced at one time. It is clear, of course, that the economies of line maintenance, work load in any year, joint use and other management considerations will have a strong bearing on the decision. The inspector's recommendation in such cases should be subject to review by other interested departments.

Inspector's Equipment

The tools and implements comprising the inspector's equipment will be largely indicated by the kind of poles to be inspected, the nature of the ground and the means of transportation available. The essential tools are a "sounding" implement (such as a hatchet), an increment borer, a prod, 6-foot tape, replacement-circumference charts and wire conversion table, and, if excavating around the poles is anticipated, some convenient type of round-pointed spade or shovel. A light bar or pick may be useful for digging in hard, tight, or rocky soil.

The preferred "sounding" tool is a light ($1\frac{1}{4}$ pound) short handled hatchet. The increment borer is a standard tool designed to remove a slim core of wood from a pole

under examination. The wire conversion and replacement-circumference charts are given in REA Bulletin No. 161-4 T O & M Series entitled "Pole Inspection and Maintenance". The other tools and implements are usually and, in many cases, preferably obtained locally.

The remainder of the inspection equipment should include the necessary forms for the current inspection data, pencils, plugs for filling borer holes, etc., together with the record of next preceding inspection if any is available.

Inspection Records

Properly kept records provide the best basis for estimating the expected performance of a pole. Thus, a record of the circumference of good wood at or below the ground line of untreated poles together with dimensions of exposed or enclosed decay pockets and notation as to insect infestation will enable the inspector at any subsequent inspection to calculate a close approximation of the rate of deterioration since the preceding inspection. A record of damage by fire, storm, collision, or woodpeckers where the damage is not considered sufficient at the time to warrant replacement will assist the inspector at subsequent inspections in deciding what action should then be taken.

The Technique of Inspection

The technical skill necessary for competent inspection of poles in line is not difficult to acquire, but it is generally under-emphasized in the training of inspectors. The external forms of deterioration can be readily observed and measured and the internal condition of a pole can be determined with reasonable accuracy by sounding and boring.

Sounding a pole means striking or tapping it lightly with a hatchet or similar tool. The tool should be held firmly but not rigidly and the blow should be delivered lightly with a forearm and wrist motion, and the face of the tool should meet the surface of the pole squarely. The sound emitted by the pole varies with its internal condition; a pole free from internal decay, insect damage or other imperfections sounds solid, whereas a decaying pole or one extensively riddled by insects sounds dull or hollow.

The natural resonance of a solid pole may be altered by the weight of a heavy load, or by heavy guying, or by a water soaked interior or surface, or by a shake within about two inches from the surface, or by large checks. The inspector therefore must acquire by experience the ability correctly to diagnose the sound he hears, and in all cases of doubt as to the internal condition of the pole he should use the increment borer.

The increment borer is a competent tool when properly handled. Like any cutting tool the edge should be protected from damage. When using the borer below the ground line care should always be taken to see that the pole surface at the point to be bored is free from dirt and grit. The borer should be turned with steadily applied force to avoid breaking the shaft. It should always be directed as nearly horizontal as possible (when boring standing poles) toward and to the center of the pole. In a properly taken boring the annual growth rings are approximately at right angles with the lengthwise axis of the core. The bore of the tool should always be clear of obstruction before starting the boring , for if not, the obstruction may cause the core of

wood to jam in the borer, or interfere with insertion of the extractor and if force is then used to pass the obstruction the almost invariable result is a plugged borer. The core is removed by inserting the extractor, making sure that the tip passes the outer end of the core freely; the extractor is then pressed in until it binds snugly but not tightly. The bit is then reversed about one half turn, and the extractor and core withdrawn together.

The increment borer core is a real sample of the wood at the location from which it is taken. If the wood is unaffected by fungi, it is flexible to a considerable degree and generally has a characteristic odor. The cedars have a spicy odor; pine has an odor of turpentine, although usually the creosote in treated pine masks the natural odor. The odor of cedar is usually fairly strong, but lack of odor need not arouse suspicion as to the condition of the wood provided the other characteristics of sound wood are present. If the wood is affected by fungi the core, even if it has been withdrawn without breaking, has practically no flexibility and breaks very easily; it usually has a distinct moldy or rotten wood smell. It is imperative, in the interest of saving poles, that enough borings should be taken in all cases of a deteriorating pole to determine the extent to which it is actually deteriorated.

The increment borer is of special utility in the inspection of creosoted southern pine and Douglas fir poles. A small percent of these poles may sound hollow when tested by tapping. In many cases the apparent hollowness is confined to less than one-fourth of the circumference. A very few poles may be found which sound hollow when tapped over the whole circumference. When the hollow "sound" appears to be confined in one quadrant of the pole, it may be due to localized decay in untreated inner sapwood, or to a "shake" within about two inches from the surface. In the latter case, there is usually a fairly wide check about in the middle of the hollow-sounding portion, and a core taken at either side of the check will be found to be solid except for a clean separation at the shake. These shakes are a natural characteristic of creosoted pine and Douglas fir poles and are not considered detrimental to the life or strength of the pole. When the hollowness is caused by decay a core taken at about the middle of the hollow-sounding region reveals the depth of penetration over the decay pocket, this depth being the present or ultimate thickness of solid "shell" over the region of decay. Additional borings should be taken at about the same level where the pole sounds solid. If by reason of greater penetration at these points it is evident that the decay will be confined to its present extent the deterioration is appraised on the basis of an enclosed pocket or on thickness of shell. If the depth of penetration at these points is less than the admissible shell thickness, indicating that eventually the pole will be inadequate, the immediate decision is based on judgment as to whether the pole should be reported for routine removal or for re-examination at the next regular inspection.

Inspection Procedure

It has been pointed out that the inspector's procedure should follow a general routine, varied according to circumstances, rather than adhere rigidly to a set of rules and mathematicl formulae. What follows here is a presentation of a procedure that has been found to facilitate the work of inspection and appraisal.

In general an inspector with one assistant is sufficient; in some cases two assistants will speed up the work. In other cases, notably where very little or no excavating need be done the assistant may not be needed regularly, and may then be engaged locally by the day.

The inspector should have all the necessary engineering information relating to the poles or the line he is to inspect. This information should include class of line, storm loading, and any prospective or planned changes in attachments, re-routing and the like within the next inspection interval. He should also have the previous inspection report if available.

The first approach to a pole should be with consideration as to whether, aside from any question of its physical condition, it should be retained in line in its present setting. As it stands the pole may be a public hazard, or interfere with convenient passage of traffic; it may lean out of line badly, it may be too short for present or planned purposes. Obviously, if a pole is to be replaced for reasons not associated with its physical condition, there would be no need to make a detailed inspection, unless it might be useful in deciding whether the pole could be used elsewhere.

The next step if the pole is to remain in line is to inspect it for damage above the ground line, that is for storm, fire, collision or woodpecker damage, and in the case of butt treated cedar poles for decayed sapwood or "shell rot". Some cedar poles, particularly those having thicker than average sapwood are likely to have only a thin shell covering a completely decayed sapwood after 12 to 15 years in service. This sapwood decay is a potential menace to linemen at work on the pole, and care should be taken to discover it.

The appropriate next step if the pole is not to be removed for damage above ground or for other reasons is to determine the internal condition above the ground line. A small percent of poles may be infested with carpenter ants or may have hollow heart or enclosed decay pockets above the ground line. Sounding by tapping lightly with the hatchet can usually be relied upon for detection of hollow heart, internal decay or ant workings. The extent of the damage should be determined by means of the increment borer. If the pole is solid or if not sufficiently deteriorated internally to warrant removal the inspector proceeds with ground line inspection when there is reason to suspect failure of the treatment or the presence of internal decay. Inspection of the ground line condition of pressure treated poles should be carried out on a sampling basis, judgment being made after examination of representative poles for a given suppliers production for a given year. These data have been branded at ten feet from the butt of all poles since 1931.

For purposes of ground line inspection, the soil should be removed from around the pole to a depth of about twelve inches, unless as the digging proceeds it is evident from the condition of the pole that no more needs to be done. In sandy or gravelly soils the excavation should be six to 12 inches deeper; in very wet, or swampy soils excavation is not usually needed. Inspection of the below-ground section of the pole is made in the same manner as above ground for internal decay, that is by sounding and using the increment borer. Where there has been external deterioration (decay) because of preservative failure, the examination is to determine the loss of wood by decay and the circumference of the core of sound wood remaining. This circumference can be determined in several ways with reasonable accuracy. The decayed and partially decayed wood can be removed as by scraping with some suitable dull edged tool, and then measuring the remaining circumference; or, the remaining circumference can be calculated by deducting from the original circumference, six times the average depth of decay as determined by probing at several points around the periphery pole. Preferably, the remaining circumference can be calculated from 3 or 4 borings equally spaced around the periphery; the unsound portion is discarded and only the remaining length to the pith center of the

pole is retained for measurement. This length then represents the radius of the sound core; the average of the borings so taken multiplied by 6 is approximately the circumference of the sound core. If this circumference is at least one inch greater than the required circumference at replacement, the pole may be considered suitable for ground line treatment. All exploratory holes are to be plugged with a decay resistant wood plug.

Synopsis of Pole Inspection Procedure

Crew - Inspector and one helper

Tools - Inspector's - increment borer, pole prod, hatchet, circumference tape, pole line records and previous inspection record, current inspection forms, wire conversion table and replacement circumference charts. Supplementary equipment, pencils, 6-inch rule.

Helper's - shovel or spade, light digging bar, plugs for filling increment borer holes.

Procedure - All poles. If pole is not to be removed, as for example for line change or respacing,

1. Examine entire above ground section

   1.1 for damage from collision, fire, storm, woodpeckers and for split top, breakage, etc.

   1.2 for inadequate height for clearance, either present or prospective, for interference with other services or structures, or with trees where trimming rights cannot be obtained, and for public hazard.

2. If pole is marked for removal because of damage (1.1) or for other reasons (1.2) or is not considered for re-use do no further work, otherwise proceed with inspection for internal condition above the ground line.

3. Sound the pole all around from close to the ground line upward as high as can be conveniently reached. If any internal decay, hollow or insect attack is suspected, determine extent of damage by additional careful sounding and use of the increment borer. If the pole is unfit for further service because of internal deterioration or extensive ant damage or if infested and no steps are to be taken to destroy the ants, mark the pole for replacement. Otherwise proceed with ground line inspection if the pole is cedar, western larch or creosoted pine or Douglas fir more than 20 years old except where the poles stand in swampy soil and are certain to be water soaked below the ground line, or where there is suspicion of preservative failure below ground line.

4. Excavate to a depth of about 12 inches all around unless before this has been done it is obvious that the pole is unfit to remain in line, in which case mark the pole for replacement.

5. Inspect the below-ground line section of the pole for external decay and for hollow heart and internal decay. If the pole is obviously considerably in excess of the replacement circumference, inspect first for its internal condition. If the pole is hollow or decayed and the thickness of sound shell is less than the minimum specified, or if it is clear that the deduction for hollow heart plus that to be made for external decay will reduce the equivalent circumference below the specified minimum, mark the pole for replacement. Otherwise proceed with determination of external decay. Locate the level of the deepest external decay and determine the equivalent circumference of good wood remaining. If the net circumference is less than the specified minimum making the pole undersize, mark the pole for undersize, mark the pole for prompt replacement, unless circumstances justify routine replacement. Plug all exploratory holes in poles which are to remain in place, using decay resistant (treated) wood plugs, or plugs made of black locust.

6. Estimate remaining pole life and date of, or years to, next inspection.

7. The inspection record should show --

   (a) the reason for condemnation.

   (b) the estimated circumference of good wood below ground line.

   (c) the next inspection date (year) or years to next inspection.

   The reason or reasons for condemnation should be definite. Thus, for reasons under (1) above, state --

   <u>Damage,</u> by collision, fire, storm, woodpeckers or split top, or

   <u>Insufficient clearance</u>, trees or other services, or

   <u>Line change</u>

   for reasons under (3) above, state hollow heart, internal decay, or ants or termites above ground,

   for reasons under (5) above, state hollow heart, external decay (preservative failure), ants, termites, or undersize, as the case may be.

   The estimate of remaining good wood should be recorded because it will be of material assistance at the next inspection in determining the rate of deterioration and in estimating remaining life.

   The next inspection date or years to next inspection should be recorded because it will assist greatly in planning subsequent inspection work load.

GROUND LINE TREATMENT

This is a supplementary treatment to be applied only when

(a) the portion of the pole above the ground appears to be adequate for at least 5 years and does not offer unusual hazard to men climbing or working on the pole.

(b) there is at least one inch of good wood in excess of the replacement circumference.

Preservatives

The preservatives suitable for this work are,

(a) Coal Tar Creosote for Non-pressure Treatments, per AWPA Standard Specification P 7-54

(b) Penta-petroleum Solution containing 5% of pentachlorophenol, per AWPA Standard Specification P 8 and P 9.

The creosote can be obtained in portable quantities up to 55 gallons (in drums); the pentachlorophenol can be obtained in dry (crystal) form and mixed with petroleum (such as household fuel oil) or preferably it can be purchased in a concentrated liquid (oil) form for further dilution in petroleum as desired.

Application of the Preservative

Either of these preservatives can be applied at atmospheric temperature above freezing (preferably above 50°) through any convenient means, such as a watering can, without the spray head, when only a few poles are to be treated; or with an ordinary garden pressure sprayer with the spray nozzle removed; or an Indian fire pump or its equivalent. Pressure however is not necessary.

In a large scale operation it will be advantageous to provide equipment to transport and apply the preservative. There is no standard equipment however; it is a matter of adaptation of available apparatus designed for somewhat similar use.

Preparation of the Pole for Treatment

When the thickness of decayed wood on the surface of the pole exceeds about one-half of an inch, it should be removed by scraping with a dull edged tool down to firm wood. Care should be taken to remove as little firm or sound wood as practicable.

It is not generally necessary to delay application of the preservative until the pole surface has dried.

Procedure for Ground Line Treatment (External)

The treatment is preferably and for economic reasons done in connection with inspection. On completing the inspection, the excavation is loosely refilled to about half its original depth. The soil is then pressed away from the entire periphery of the pole to about the depth of the refill, thus making a V-shaped trench surrounding the

pole. Approximately 2 quarts of the preservative are then applied against and all around the pole at about 12 inches above the ground level, especial care being taken that the oil enters into any checks and exposed decay pockets. Back filling of the excavation is then completed, taking care that the preservative which has flowed into the trench stays there. On completion of the back fill, which may be tamped as desired, another V-shaped trench is formed to about the upper level of the preceding one. Another two quarts of preservative are applied as before, after which, the trench is closed by pressing the soil slowly against the pole.

Procedure for Internal Treatment

Internal treatment may be necessary to combat infestation of carpenter ants and subterranean termites, especially in western red cedar.

Where these insects are prevalent in a region they are usually to be found in a few poles, and unless exterminated are capable of very materially weakening a pole.

The external ground line treatment generally will suffice to destroy an infestation of subterranean and damp wood termites, but it may be considered good practice to apply an internal treatment as well, using the same preservatives although creosote, because of its strong fumes appears to reach any insects which may not be actually in contact with the oil itself.

The preservative is conveniently introduced through two or more increment borer holes, bored to intersect the inner galleries or chambers of the insects. These are intricately connected so that penetrance of any of them usually gives sufficient access to the whole labyrinth. An ordinary heavy grease gun, like those used in garages, provided with an extended nozzle of about 4 inches length, has been used satisfactorily for injecting the preservative. Approximately one pint of the oil injected into each hole has been found to be completely effective. The holes bored for this treatment need not be plugged.

This has been a presentation of some of the important aspects of pole design, procurement, use, and maintenance. It has not been practicable to cover the subjects in complete detail, and it is likely some aspects may have been omitted. Consequently, a discussion period is now in order.